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Formative Quizzing and Learning Performance in Dutch First-Year Higher Education Students

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Abstract. In this research paper, a cross-sectional study into the effects of formative quizzing in higher education and its relation to learning performance is presented. For the current study, six online Formative Quizzing modules, consisting of texts, graphics and video clips followed by two or more test questions to reiterate the material, were provided to students. Students could not earn marks and were free to use the material, but were informed that in the final examination, questions relating to the material would be asked. Data analysis showed that students who completed all six modules had a statistical significant higher chance to score better on the final examination. This was true for high achieving students, but also, and even stronger, for low achieving students. The results therefore show in this particular set-up a potential causal relationship of online formative quizzing on learning performance in higher education.

Keywords: Online quizzing · Formative assessment · Formative quizzing · Learning performance · Deep learning · Self-study

1 Introduction

Formative assessment or quizzing is widely used in higher education, both in the more traditional classroom settings and online. Online formative assessment offers several opportunities such as (formative and) immediate feedback, student (and teacher) engagement in critical learning processes and personalized education [1]. Although these opportunities offer the possibility to enhance student performance, research regarding the extent of learning performance of using (online) formative quizzes is not conclusive [2]. Various studies have demonstrated one or several factors contributing to this testing effect such as time on task [3], question type [4] and feedback [5]. However, regardless of the type of factor studied, some studies report a negative effect or no effect of formative assessment [6, 7], other report a positive effect [5, 7, 8]. This difference in outcome that can be explained, among others, by the fact that laboratory studies often find effects that cannot be reproduced in the classroom, and therefore require careful interpretation [9, 10].

In this research paper, a cross-sectional study into the effects of formative quizzing in higher education and its relation to learning performance is presented. The aim of the

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study was to investigate if formative quizzing results in better learning performance among Dutch first-year higher education students.

2 Methods

This study was conducted in the first-year Bachelor course Human Life Cycle II, within the Health and Life Sciences Program, at the VU University, Amsterdam, The Netherlands. The Bachelor program compromises both a biomedical and a health sciences view on human health and disease. The course Human Life Cycle II, which is the fifth and final course of the first semester, covers an overview of human development, health and disease from early childhood until senescence, which includes topics such as psychomotor development of children, puberty and diseases of aging. Students were able to participate in lectures, practical's, group meetings and online quizzing. For the topic puberty, six online Formative Quizzing modules were designed to improve student's deep learning.

The six online Formative Quizzing modules compromised online instructional material regarding the topic and consisted of texts, graphics and video clips followed by two to nine (on average six) multiple choice and fill-in-the-blanks questions to reiterate the material. The students were free to use the modules at their own time and place and could not earn marks for completing them. The information in the modules was not covered by tutors in face-to-face meetings. The modules were available during the course until the final examination. To create the Formative Quizzing modules Easy-Generator was used, which allowed the design of easy accessible and attractive online modules.

Data on the completion of each of the six online Formative Quizzing modules and examination grades and scores were collected. Data on the completion of the online Formative Quizzing modules were coded 'not completed' (none of the six modules completed) or 'completed' (all six modules completed). For the examination, a total of 225 points could be earned with a passmark of 145 points. The examination included four test items that covered the topics assessed in the Formative Quizzing modules ('topic-covering questions') for a total of 13 points. These four topic-covering questions included both multiple choice questions as fill-in-the-blanks questions and were therefore similar to the type of questions in the Formative Quizzing modules. A passmark for the four topic-covering questions was set at three or four correct questions.

The data were processed and analyzed in IBM SPSS Statistics (version 21). Chi-square tests were used to study the relationship between Formative Quizzing completion (not-completed or completed) and the examination (pass or fail) and topic-covering questions (pass or fail).

3 Results

In total 319 students participated in the course Human Life Cycle II and completed the final examination. Information regarding demographic factors was unavailable for privacy reasons. Data on the completion of the six modules showed that 92 students (29 %) did not complete any Formative Quizzing modules, 105 students (33 %)

completed one to five modules and 122 (38 %) completed all six Formative Quizzing modules. Within the group that completed one to five modules, no pattern was found on which modules were always or never completed. In this study, students who did not complete any Formative Quizzing module were compared to students who completed all modules.

The Chi-square test showed that students who completed all Formative Quizzing modules had 3.7 (CI: 1.6–8.4) higher odds to pass the examination compared to students who completed no Formative Quizzing modules at all (Table 1).

Table 1. Formative quizzing modules (none-completed versus all-completed) and failed or passed examination (OR = 3.7 (CI: 1.6–8.4) (N = 214))

Formative quizzing modules	Number of students (%)		
	Failed examination	Passed examination	Total
None	40 (43)	52 (57)	92 (100)
All	21 (17)	101 (83)	122 (100)
Total	61 (28)	153 (72)	214 (100)

The Chi-square test showed that students who completed all six Formative Quizzing modules had 4.9 (CI: 2.6–9.2) higher odds to successfully pass all four topic-covering questions compared to students who completed no Formative Quizzing modules at all (Table 2).

Table 2. Formative quizzing modules (none-completed versus all-completed) and failed or passed topic-covering questions (OR = 4.9 (CI: 2.6–9.2) (N = 214))

Formative quizzing modules	Number of students (%)		
	Failed topic-covering questions	Passed topic-covering questions	Total
None	45 (49)	47 (51)	92 (100)
All	20 (16)	102 (85)	122 (100)
Total	65 (30)	149 (70)	214 (100)

An analysis on topic-covering questions was made by comparing students who passed or failed the examination. Of the students who passed the examination, those who completed all six Formative Quizzing modules had 3.0 (CI:1.4–6.6) higher odds to successfully answer all four topic-covering questions compared to those who completed no Formative Quizzing modules at all (Table 3). Of the students who did not pass the examination, those who completed all six Formative Quizzing modules had 6.7 (CI: 2.0–22.3) higher odds to successfully answer four topic-covering questions compared to those who completed no Formative Quizzing modules at all (Table 4).

Table 3. Formative quizzing modules (none-completed versus all-completed) and failed or passed topic-covering questions for students who passed examination (OR = 3.0 (CI:1.4–6.6) (N = 153))

Formative quizzing modules	Number of students who passed examination (%)		
	Failed topic-covering questions	Passed topic-covering questions	Total
None	18 (35)	34 (65)	52 (100)
All	15 (15)	86 (85)	101 (100)
Total	33 (22)	120 (78)	153 (100)

Table 4. Formative quizzing modules (none-completed versus all-completed) and failed or passed topic-covering questions for students who failed examination (OR = 6.7 (CI: 2.0–22.3) (N = 61))

Formative quizzing modules	Number of students who failed examination (%)		
	Failed topic-covering questions	Passed topic-covering questions	Total
None	27 (67)	13 (33)	40 (100)
All	5 (24)	16 (76)	21 (100)
Total	32 (52)	29 (48)	61 (100)

4 Discussion

The results show a possible causal relationship of online formative quizzing on learning performance in higher education. It demonstrates that students who completed all Formative Quizzing modules, had a higher change to pass the examination and the four questions that covered the topic in the Formative Quizzing modules. Moreover, students who failed the examination but completed all Formative Quizzing modules, had a higher chance to pass topic-covering questions compared to the students who failed the examination and did not complete any Formative Quizzing module.

In this study, a positive effect of the Formative Quizzing modules is therefore less related to overall performance. That is, a significant finding as overall performance is in general an underlying variable expressing motivation and persistence, which therefore explains much of the variance between performance on course related activities and achievement. The positive effect of the Formative Quizzing modules on achievement found in this study is likely to be explained by the fact that the actual engagement of the students with the formative quizzing resulted in better retention and deeper learning.

Of interest regarding this study is the participation (69 %) of students in Formative Quizzing without an incentive (e.g. grade mark for completion). Although previous research demonstrated that student participation increases when incentives are offered [11, 12], it was also shown that students can use questionable methods to achieve these credits [12]. More recently it is recommended to boost voluntary participation in online

formative quizzing [13]. In this study, the Formative Quizzing modules were designed to engage students and thereby increasing the participation without the need for incentives. Additional focus groups and questionnaires (not reported) showed that students were indeed positively engaged by the design of the Formative Quizzing modules, highlighting the design of formative quizzing modules as an opportunity to increase participation.

The findings are supported by other studies [5, 8], although literature is not conclusive [2, 6]. However, comparing studies is difficult because of the use of different methodology (laboratory- versus classroom-based). A standardized methodology could aid in a better understanding of the complexity of this relationship and could explain differences found in this and other studies.

The strength of this study lies in the fact that data collection and registration were executed objectively and anonymously, which limits the chance on selection bias. Data were derived directly from Blackboard and examination grades were derived from the digital examination.

Although this study was able to distinguish between good and poor performance based on the examination grade, the effects that were found may still be partially influenced by the effect of students with a good study performance who study all materials offered. The conclusions of this study would gain strength by including students overall study performance as a covariate.

A limitation is that the current study did not include the moment at which the quizzes were taken and the amount of time spent on the task due to technical difficulties. It is known that formative quizzes can have a beneficial as well as detrimental effect on performance, depending on the moment of the quizzes in relation to the final test [8, 14]. Furthermore, research has shown that more time on task correlates with learning performance [3]. Therefore, further analyses that would include the moment of quizzing and amount of time spent, would provide a more thorough understanding of the relationship between formative quizzes and final test outcome.

Another limitation is the exclusion of the group of students that completed 1 to 5 modules. Future analysis of this group would offer a better understanding of the relation between online formative assessment and student performance.

Regarding the positive results presented in this paper, it is recommended to use Formative Quizzing in higher education. However, in the current study, the Formative Quizzing modules were related to only one topic of the course. Future research is needed to show what would happen with students engagement and learning performance with online materials if larger parts of the course, or the whole course, were provided to students in this manner. It is by studying formative quizzing that we aim to address the value of adding this type of education to higher education curricula.

This study showed a significant and most likely causal positive effect of providing online instructional materials with formative quizzes to higher education students reinforcing learning. This study shows that this instructional method is viable to be incorporated in higher education curricula.

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